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A HYBRID GROUP ACCEPTANCE SAMPLING PLANS FOR LIFE TESTS BASED ON THE EXPONENTIATED INVERTED WEIBULL DISTRIBUTION

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Abstract

When the lifetime of an item follows an exponentiated inverted Weibull distribution, a hybrid group acceptance sampling method based on truncated lifetimes is developed in this article. The minimum number of testers and acceptance number required for a particular group size are determined for a specified consumer risk and test termination time. The minimum ratios of the true average life to the stipulated life at a certain producer's risk are determined using the values of the operational characteristic function for various quality levels. Examples are used to demonstrate the results.

1. Introduction

Acceptance or rejection of a product is based on its suitability for use. There are various sorts of quality checking processes used in quality control. Acceptance sampling plans are one example of such a procedure. An

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acceptance sampling plan is a method for determining the minimal sample size for testing. This is especially essential if the quality of a product is determined by its lifetimes. When constructing a sampling plan, it is frequently believed that only one item will be placed in a tester. In practise, however, testers who can handle a large number of items at once are used since testing time and money can be saved by evaluating objects at the same time. A group of objects in a tester can be considered, and the number of items in a group is referred to as group size. A group acceptance sampling plan (GASP) is an acceptance sampling plan based on a group of objects. The hybrid group acceptance sampling plan (HGASP) is a way of calculating the minimal number of items for a predetermined number of groups. When the HGASP is combined with truncated life tests, it is referred to as an HGASP based on truncated life tests, which assumes that the product's lifetime follows a given probability distribution.

Srinivasa Rao's research on the hybrid group acceptance sampling plan (HGASP) of truncated life tests is available [10] [11], Razzaque [8], Ramaswamy and Anburajan [4], [5], [6], [7], Hussain et al. [2], Srinivasa Rao [12], Subba Rao et al. [13], Rajagopal and Vijayadevi [3], Sandeep Kumar [9].

In section 2 of this study, we explain a proposed hybrid group acceptance sampling plan (HGASP) based on truncated life tests where a product's lifetime follows an exponentiated inverted Weibull distribution. Section 3 discusses operating characteristics (OC) and producer risk. Section 4 explains the results with some instances, and section 5 concludes with a summary and conclusions.

2. The Hybrid Group Acceptance Sampling Plans (HGASP)

The Exponentiated Inverted Weibull Distribution (EIWD) probability density function (pdf) is given by

$$f(x) = \theta\beta x^{-(\beta+1)}(e^{-x^{-\beta}})^{\theta} x > 0, \beta > 0, \theta > 0 \tag{2.1}$$

It has a cdf (cumulative distribution function).

$$F(x) = (e^{-x^{-\beta}})^{\theta} x > 0, \beta > 0, \theta > 0 \tag{2.2}$$

The hazard function is

$$h(x) = \frac{\theta\beta x^{-(\beta+1)}(e^{-x^{-\beta}})^{\theta}}{1-(e^{-x^{-\beta}})^{\theta}} \tag{2.3}$$

On the positive real line, the Exponentiated Inverted Weibull Distribution is a skewed, unimodal distribution. EIWD's Kth moment and median are calculated as follows:

$$E(x^k) = \theta^{\frac{k}{\beta}}\Gamma\left(1-\frac{1}{\beta}\right). \tag{2.4}$$

$$\text{Median } = \left(\frac{\theta}{\text{In } 2}\right)^{\frac{1}{2}} \tag{2.5}$$

The biggest order statistics $X(n)$ have a pdf that is given by

$$\alpha_{(n)} = n\theta\beta x^{-(\beta+1)}(e^{-x^{-\beta}})^{\theta}[(e^{-x^{-\beta}})^{\theta}]^{n-1} \tag{2.6}$$

The smallest order statistics $X(1)$ have a pdf that is given by

$$\alpha_{(n)} = n\theta\beta x^{-(\beta+1)}(e^{-x^{-\beta}})^{\theta}[1-(e^{-x^{-\beta}})^{\theta}]^{n-1} \tag{2.7}$$

The other distributional properties are thoroughly discussed by Flaih et al. (2012) [1].

Assume that a product's lifetime is controlled by an Exponentiated inverted weibull distribution with σ as the scaling parameter. $F(\cdot)$ is the cumulative distribution function of it.

$$F(t) = (e^{-\left(\frac{t}{\sigma}\right)^{-\beta}})^{\theta} \tag{2.8}$$

Given $0 < q < 1$, the 100^{th} percentile is given by

$$t_q = \sigma\left(-\frac{1}{\theta}\log(q)\right)^{\frac{1}{\beta}} \tag{2.9}$$

In the scaled version, we get by substituting σ in the equation 2.8.

$$F(t) = [e^{-\delta^{-\beta\left(\frac{1}{\theta}\log(q)\right)^{-1}}}]^{\theta} \tag{2.10}$$

where $\delta = \frac{t}{t_q}$. In life testing, it is usual practice to terminate the test at a predetermined period t, need a probability of rejecting a bad lot of at least p^*, and have the maximum permitted number of defective items to accept the lot equal to c. Under a truncated life test, the acceptance sampling plan for percentiles is to establish the minimum sample size n for a particular acceptance number c so that the consumer's risk, the probability of accepting a bad lot, does not exceed $1 - p^*$. The genuine 100^{th} percentile t_q, is below a stated percentile t_q^0, in a bad lot. As a result, the probability p^* is a confidence level in the sense that the probability of rejecting a bad lot with $t_q < t_q^0$ is at least p^*. Therefore, for given p^*, the proposed acceptance sampling plan can be characterized by the triplet $(n, c, \delta) = (n, c, \frac{t}{t_q^0})$ where $\delta = \frac{t}{t_q^0}$. When a distribution is symmetric, the mean and median are clearly the same. When the distribution is skewed, that is, one side of the tail is longer than the other, the mean is expected to tend towards that side of the distribution. We can make the mean considerably greater and bigger by increasing the amount of skewness, in which case the proportion of the population below the mean can be made excessively enormous. This is what it means when someone says that the mean would not represent the distribution's centre because more than 80% of the population could be below the mean. However, if the median is used, there is always 50% of the population less than the median. We use $q = 0.50$ because the median is a better approximation of the population mean for making decisions regarding quality of life in our present skewed population. As a result, we may conclude that EIWD sampling plans based on population median are more cost-effective in terms of sample size than those based on population mean.

Let μ be the true value of the median of a product's life time distribution, and μ_0 be the specified median, assuming that an item's life time follows the

Exponentiated inverted Weibull distribution. We want to test the hypothesis $H_0 : \mu \geq \mu_0$ against $H_1 : \mu < \mu_0$ based on the failure data. If the sample information supports the hypothesis, a lot is regarded good and accepted for consumer usage if $\mu \geq \mu_0$, but if $\mu < \mu_0$, the lot of the product is rejected. This hypothesis is tested in an acceptance sampling plan based on the number of failures from a sample in a pre-determined time. We reject the lot if the number of failures exceeds the action limit c. Well take it all if there's enough proof that $\mu \geq \mu_0$ at a specific level of consumer risk. Otherwise, we would reject the entire lot. Based on the truncated life test, let us suggest the following HGASP:

1. Determine the number of testers r and allocate the r items to each specified group g, with $n = g * r$ being the required sample size for a lot.

2. Pre-fix the acceptance c for each group and the time t_0 for the experiment.

3. Accept the lot if each of the groups has at least c failures.

4. Stop the experiment if any group has more than c failures and reject the whole lot.

The number of testers r necessary for an exponentiated inverted weibull distribution with various values of acceptance number c is of interest, with the group size g and termination time t_0 assumed to be known. We will accept $t_0 = \delta\mu_0$ for a given constant δ (termination ratio) since it is convenient to fix the termination time as a multiple of the provided value μ_0 of the median. The producer's risk is the probability (α) of rejecting a good lot, whereas the consumer's risk is the probability (β) of accepting a bad lot. The recommended sample plan's parameter value g is determined to ensure the consumer's risk β. Often, the consumer's risk β is expressed by the consumer's confidence level. If the confidence level is p^*, then the consumer's risk will be $\beta = 1 - p^*$. We will determine the number of groups g in the proposed sampling plan so that the consumer's risk does not exceed a given value β. We can use the binomial distribution to create the HGASP if the lot size is large enough. According to the HGASP, a lot of products is only acceptable if each of the g groups has at most c failures. As a result, the probability of a lot being accepted is given by

$$\left(\sum_{i=0}^{c}\binom{r}{i}p_0^i(1-p_0)^{r-i}\right)^g \leq \beta \tag{2.11}$$

Where $p_0 = F_t(\delta_0)$ is the probability of a failure during the time $t = \delta t_q^0$. To save space, only the result of small sample size for $\beta = 0.25, 0.10, 0.05, 0.01$; $g = 2, \ldots, 10$; $c = 0, \ldots, 8$; $\delta = 0.7, 0.8, 1.0, 1.2, 1.5, 2.0$ displayed in table 1.

Table 1. Minimum number of testers (r) required for the proposed plan in the case of EIWD.

β	G	C	Δ					
			0.7	0.8	1.0	1.2	1.5	2.0
0.25	4	0	2	1	1	1	1	1
0.25	4	1	3	3	3	2	2	2
0.25	4	2	5	4	4	4	3	3
0.25	5	3	6	6	5	5	4	4
0.25	6	4	8	7	6	6	6	5
0.25	7	5	10	9	8	7	7	6
0.25	8	6	11	10	9	8	8	7
0.25	9	7	13	12	10	10	9	8
0.25	10	8	15	13	12	11	10	9
0.10	2	0	2	2	2	2	1	1
0.10	3	1	4	4	3	3	3	2
0.10	4	2	6	5	4	4	4	3
0.10	5	3	7	7	6	5	5	4
0.10	6	4	9	8	7	6	6	5

0.10	7	5	11	10	8	8	7	7
0.10	8	6	12	11	10	9	8	8
0.10	9	7	14	13	11	10	9	9
0.10	10	8	16	14	12	11	11	10
0.05	2	0	3	3	2	2	2	1
0.05	3	1	5	4	3	3	3	2
0.05	4	2	6	6	5	4	4	4
0.05	5	3	8	7	6	6	5	5
0.05	6	4	10	9	7	7	6	6
0.05	7	5	11	10	9	8	7	7
0.05	8	6	13	12	10	9	9	8
0.05	9	7	15	13	11	11	10	9
0.05	10	8	17	15	13	12	11	10
0.01	2	0	4	4	3	3	2	2
0.01	3	1	6	5	4	4	3	3
0.01	4	2	7	7	6	5	4	4
0.01	5	3	9	8	7	6	6	5
0.01	6	4	11	10	8	7	7	6
0.01	7	5	13	11	10	9	8	7
0.01	8	6	14	13	11	10	9	8
0.01	9	7	16	14	12	11	10	9
0.01	10	8	18	16	14	12	11	11

3. Operating Characteristic of the Sampling Plan

The deviation of the defined value μ_0 of the median from its true value μ can be viewed as a function of acceptance probability. This function is called operating characteristic (OC) function of the sampling plan. After obtaining the least number of testers r, one may be interested in determining the probability of a lot being accepted when the quality is regarded good if $\mu \geq \mu_0$ or $\frac{\mu}{\mu_0}$. The OC is handed out by

$$L(p) = \left(\sum_{i=0}^{c} \binom{r}{i} p^i (1-p)^{r-i} \right)^g \tag{3.1}$$

Using Equation 3.1 the OC values can be obtained for any sampling plan. To save space we present the OC values for sampling plans with $\frac{\mu}{\mu_0} = 2, 4, 6, 8, 10, 12;$

$\beta = 0.25, 0.10, 0.05, 0.01; \delta = 0.7, 0.8, 1.0, 1.2, 1.5, 2.0$ are given in table 2.

Producer's Risk

The producer may be interested in improving the product's quality so that the acceptance probability exceeds a predetermined level. The smallest ratio can be determined by satisfying the following inequality for a given value of the producer's risk, say α.

$$\left(\sum_{i=0}^{c} \binom{r}{i} p^i (1-p)^{r-i} \right)^g \geq 1 - \alpha \tag{3.2}$$

To save space, the time minimum values of the ratio $\frac{\mu}{\mu_0} = 2$ in case of Exponentiated inverted weibull distribution based on the values given in table 1 for the acceptability of a lot at the producer's risk of $\alpha = 0.05$ are presented in table 3.

Table 2. Operating characteristic values of the HGASP with $c = 2$ for EIWD.

β	r	D	$\frac{\mu_0}{\mu}$					
			2	4	6	8	1	12

0.25	5	0.7	0.0567	0.0001	0.0000	0.0000	0.0000	0.0000
0.25	4	0.8	0.1195	0.0003	0.0000	0.0000	0.0000	0.0000
0.25	4	1.0	0.3027	0.0041	0.0000	0.0000	0.0000	0.0000
0.25	4	1.2	0.5035	0.0197	0.0003	0.0000	0.0000	0.0000
0.25	3	1.5	0.7364	0.0850	0.0041	0.0001	0.0000	0.0000
0.25	3	2.0	0.9189	0.3027	0.0416	0.0041	0.0003	0.0000
0.10	6	0.7	0.2070	0.0003	0.0000	0.0000	0.0000	0.0000
0.10	5	0.8	0.3778	0.0016	0.0000	0.0000	0.0000	0.0000
0.10	4	1.0	0.7029	0.0184	0.0001	0.0000	0.0000	0.0000
0.10	4	1.2	0.8878	0.0809	0.0016	0.0000	0.0000	0.0000
0.10	4	1.5	0.9788	0.2892	0.0184	0.0007	0.0000	0.0000
0.10	3	2.0	0.9988	0.7029	0.1583	0.0184	0.0016	0.0001
0.05	6	0.7	0.3053	0.0004	0.0000	0.0000	0.0000	0.0000
0.05	6	0.8	0.5164	0.0028	0.0000	0.0000	0.0000	0.0000
0.05	5	1.0	0.8326	0.0305	0.0002	0.0000	0.0000	0.0000
0.05	4	1.2	0.9566	0.1275	0.0028	0.0000	0.0000	0.0000
0.05	4	1.5	0.9954	0.4108	0.0305	0.0012	0.0000	0.0000
0.05	4	2.0	0.9999	0.8326	0.2391	0.0305	0.0028	0.0002
0.01	4	0.7	0.5106	0.0010	0.0000	0.0000	0.0000	0.0000
0.01	4	0.8	0.7447	0.0063	0.0000	0.0000	0.0000	0.0000
0.01	3	1.0	0.9574	0.0654	0.0005	0.0000	0.0000	0.0000
0.01	3	1.2	0.9951	0.2456	0.0063	0.0001	0.0000	0.0000
0.01	2	1.5	0.9998	0.6375	0.0654	0.0028	0.0001	0.0000
0.01	2	2.0	1.0000	0.9574	0.4201	0.0654	0.0063	0.0005

Table 3. Minimum ratio of the values of true median and the specified median for the producer's risk of $\alpha = 0.05$ in the case of EIWD.

β	G	c	δ					
			0.7	0.8	1.0	1.2	1.5	2.0
0.25	2	0	2.7376	3.1286	3.9108	4.6929	5.8661	7.8214
0.25	3	1	2.0001	2.1269	2.6586	3.1903	3.9879	5.3170
0.25	4	2	2.0001	2.0002	2.1108	2.5329	3.1661	4.2213
0.25	5	3	2.0001	2.0002	2.0003	2.1410	2.6762	3.5682
0.25	6	4	2.0001	2.0002	2.0003	2.0004	2.3422	3.1229
0.25	7	5	2.0001	2.0002	2.0003	2.0004	2.0965	2.7953
0.25	8	6	2.0001	2.0002	2.0003	2.0004	2.0005	2.5416
0.25	9	7	2.0001	2.0002	2.0003	2.0004	2.0005	2.3384
0.25	10	8	2.0001	2.0002	2.0003	2.0004	2.0005	2.1709
0.10	2	0	3.5545	4.0622	5.0778	6.0933	7.6166	10.1554
0.10	3	1	2.3259	2.6581	3.3225	3.9871	4.9838	6.6450
0.10	4	2	2.0001	2.0703	2.5879	3.1054	3.8817	5.1755
0.10	5	3	2.0001	2.0002	2.1607	2.5929	3.2410	4.3214
0.10	6	4	2.0001	2.0002	2.0003	2.2494	2.8118	3.7489
0.10	7	5	2.0001	2.0002	2.0003	2.0004	2.4997	3.3329
0.10	8	6	2.0001	2.0002	2.0003	2.0004	2.2606	3.0142
0.10	9	7	2.0001	2.0002	2.0003	2.0004	2.0705	2.7606
0.10	10	8	2.0001	2.0002	2.0003	2.0004	2.0005	2.5531
0.05	2	0	4.1244	4.7136	5.8919	7.0703	8.8378	11.7837
0.05	3	1	2.6463	3.0243	3.7805	4.5365	5.6705	7.5607
0.05	4	2	2.0412	2.3327	2.9159	3.4990	4.3737	5.8314
0.05	5	3	2.0001	2.0002	2.4195	2.9033	3.6291	4.8388

0.05	6	4	2.0001	2.0002	2.0896	2.5075	3.1343	4.1790
0.05	7	5	2.0001	2.0002	2.0003	2.2216	2.7769	3.7025
0.05	8	6	2.0001	2.0002	2.0003	2.0035	2.5044	3.3390
0.05	9	7	2.0001	2.0002	2.0003	2.0004	2.2884	3.0511
0.05	10	8	2.0001	2.0002	2.0003	2.0004	2.1123	2.8164
0.01	2	0	5.3694	6.1364	7.6705	9.2046	11.5057	15.3409
0.01	3	1	3.3408	3.8180	4.7726	5.7270	7.1587	9.5450
0.01	4	2	2.5372	2.8997	3.6245	4.3494	5.4368	7.2490
0.01	5	3	2.0848	2.3826	2.9782	3.5738	4.4672	5.9562
0.01	6	4	2.0001	2.0434	2.5541	3.0649	3.8311	5.1080
0.01	7	5	2.0001	2.0002	2.2506	2.7008	3.3760	4.5011
0.01	8	6	2.0001	2.0002	2.0209	2.4252	3.0313	4.0417
0.01	9	7	2.0001	2.0002	2.0003	2.2080	2.7599	3.6798
0.01	10	8	2.0001	2.0002	2.0003	2.0317	2.5395	3.3862

4. Tables and Examples

Table 1 shows the HGASP design parameters for various values of the consumer's risk and the test termination time multiplier. It should be noted that $n = r \times g$ can be used to get the minimal sample size. Table 1 shows that when the test termination time multiplier δ increases, the number of testers r reduces, implying that if the test termination time multiplier increases for a certain group size, less testers are required. For an example, from Table 1, if $\beta = 0.10$, $g = 7$, $c = 5$ and δ changes from 0.7 to 0.8, the required values of the design parameters of HGASP change from $r = 10$ to $r = 9$. This tendency, however, is not constant because it is influenced by the acceptance rate.

Table 2 shows the probability of acceptance for the lot at the median ratio that corresponds to the producer's risk. Finally, for certain parameter values, Table 3 shows the minimum ratios of true median to defined median for the acceptance of a lot with producer's risk $= 0.05$.

Assuming that a product's lifetime follows the exponentiated inverted Weibull distribution, an HGASP should be designed to see if the median is more than 1,000 hours, with a testing time of 700 hours and four groups. The values $c = 2$ and $\beta = 0.10$ are assumed. As a result, the termination multiplier $\delta = 0.700$. The minimal number of testers necessary is calculated as $r = 6$ from Table 1. As a result, well choose a random sample of size $n = 24$ items and assign 6 items to each of the four groups. We shall accept the lot if no more than two failures occur in any of the four groups before 700 hours. We truncate the experiment as soon as the 3rd failure occurs before the 700th hour. When the true value of the median is $= 4{,}000$ hours, the probability of acceptance for this proposed sampling plan is $p = 0.2070$. The producer's risk is $\alpha = 0.7930$ if the true value of the median is 4 times the required value $\mu_0 = 1000$ hours.

Table 3 can be used to calculate the ratio required to ensure a producer's risk of $\alpha = 0.05$. For example, when $\beta = 0.10$, $r = 6$, $g = 4$, $c = 2$ and $\delta = 0.700$, the required ratio is $\frac{\mu}{\mu_0} = 2.0001$.

5. Summary and Conclusions

In the situation of an exponentiated inverted Weibull distribution, a hybrid group acceptance sampling plan based on a truncated life test is proposed in this study. When the consumer's risk (β) and other plan characteristics are given, the number of groups and acceptance number are determined. As the test termination time multiplier grows, it is seen that the minimal number of groups required lowers. Furthermore, as quality improves, the operating characteristics function grows disproportionately. When a large number of items are being examined at the same time, this HGASP can be used. Clearly, such a tester would save time and money during the testing process.

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References

[1] A. Flaih, H. Elsalloukh, E. Mendi and M. Milanova, The exponentiated inverted weibull distribution, Applied Mathematics and Information Sciences 6(2) (2012), 167-171. http://www.researchgate.net

[2] J. Hussain, A. R. Mughal, M. K. Pervaiz and U. Ali, A hybrid group acceptance sampling plans for lifetimes having generalized Pareto distribution, Journal of Statistics 19 (2012), 31-42.

[3] S. Rajagopal and K. Vijayadevi, A hybrid group acceptance sampling plans for lifetimes based on transmuted Rayleigh distribution, International Journal of Scientific Research in Mathematical and Statistical Sciences 5(4) (2018), 77-99.

[4] A. R. S. Ramaswamy and P. Anburajan, A hybrid group acceptance sampling plans for lifetimes based on inverse Rayleigh distribution, International Journal of Computational

Science and Mathematics 4(3) (2012), 249-256. http://www.ripublication.com

[5] A. R. S. Ramaswamy and P. Anburajan, A hybrid group acceptance sampling plans for lifetimes based on Weibull distribution, International Journal of Applied Mathematical Analysis and Applications 7(1) (2012), 73-80. http://www.ijma.info

[6] A. R. S. Ramaswamy and P. Anburajan, A hybrid group acceptance sampling plans for lifetimes based on exponentiated Weibull distribution, International Journal of Mathematical Archive 3(10) (2012). http://www.ijma.info

[7] A. R. S. Ramaswamy and P. Anburajan, Ahybrid group acceptance sampling plans for lifetimes based on Gamma, exponentiated log-logistic and Marshall-Olkin extended exponential distributions, Journal of Progressive Research in Mathematics 2(1) (2012), 1-12. http://scitecresearch.com

[8] M. A. Razzaque, Ahybrid economic group acceptance sampling plans for exponential lifetime distribution, Stochastics and Quality Control 26(2) (2011), 163-171. http://econpapers.repec.org

[9] Sandeep Kumar, A hybrid group acceptance sampling plans on truncated lifetests based on Sushila distribution, International Journal of Current Microbiology and Applied Sciences 8(8) (2019). http://www.ijcmas.com

[10] G. Srinivasa Rao, A hybrid group acceptance sampling plans for lifetimes based on Log-logistic distribution, Journal of Reliability and Statistical Studies 4(1) (2011), 31-40. http://www.researchgate.net

[11] G. Srinivasa Rao, A hybrid group acceptance sampling plans for lifetimes based on generalized Exponential distribution, Journal of Applied Sciences 11(12) (2011), 2232-2237. http://scialert.net

[12] G. Srinivasa Rao, Ahybrid group acceptance sampling plans for lifetimes based on generalized Rayleigh distribution, International Journal of Statistics and Economics 8(12) (2012). http://www.ceser.in

[13] R. Subba Rao, A. N. Durgamamba and R. R. L. Kantam, A hybrid group acceptance sampling plans on size biased Lomax distribution, Journal of Mathematics and Statistics 2(3) (2014), 137-141. http://www.hrpub.org